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US Army Research Laboratory

# Personnel and Vehicle Data Collection at Aberdeen Proving Ground (APG) and its Distribution for Research

by Sylvester M Nabritt, Thyagaraju Damarla, and Gary Chatters

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**by Sylvester M Nabritt, Thyagaraju Damarla, and Gary Chatters**
***Sensors and Electron Devices Directorate, ARL***

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The US Army Research Laboratory's (ARL) Networked Sensing and Fusion Branch continually strives to develop next generation unattended ground sensors (UGSs) and other sensing platforms. In support of these goals, it is a requirement to have access to seismic, acoustic, magnetic, and other sensor signatures of vehicle and people. These signature databases allow researchers to develop cutting-edge detection algorithms that detect and classify 1 or more vehicles or persons. These algorithms will be geared toward current and new UGS applications. For this effort, a team was deployed to Spesutie Island at Aberdeen Proving Ground, Maryland, to collect signatures of personnel and vehicles from July 27–30, 2015.

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## 1. Introduction

The US Army Research Laboratory's (ARL) Networked Sensing and Fusion Branch continually strives to develop next generation unattended ground sensors (UGSs) and other sensing platforms. In support of these goals, it is a requirement to have access to seismic, acoustic, magnetic, and other sensor signatures of vehicle and people. These signature databases allow researchers to develop cutting-edge detection algorithms that detect and classify 1 or more vehicles or persons. These algorithms will be geared toward current and new UGS applications.

For this effort, a team was deployed to Spesutie Island at Aberdeen Proving Ground, Maryland, to collect signatures of personnel and vehicles from July 27–30, 2015.

## 2. Data Collection Setup

The team set up several data collection nodes comprised of seismic, acoustic, and magnetic sensors, where 1 node did not have the 3-axis geophone or the 3-microphone array. The layout for the specific sensors is shown in Fig. 1. The team spent the first day setting up all the data acquisition equipment and Garmin VIRB high definition (HD) cameras were set up around the perimeter to record all activity. The blue dots indicate an UGS suite consisting of a single microphone and a z-axis seismic sensor; a red dot indicates an UGS system consisting of a 5-inch-diameter circular array of microphones and a 3-axis seismic sensor; and a black dot indicates a 3-axis magnetic sensor placed closer to the middle of 20 m by 20 m square grid shown with dotted lines. Five UGS systems from each corner of a 20 m by 20 m square and the magnetic sensors are connected to a data collection unit, which collects the data and stores them in a file. The data are collected for a stretch of 5 min at a time.

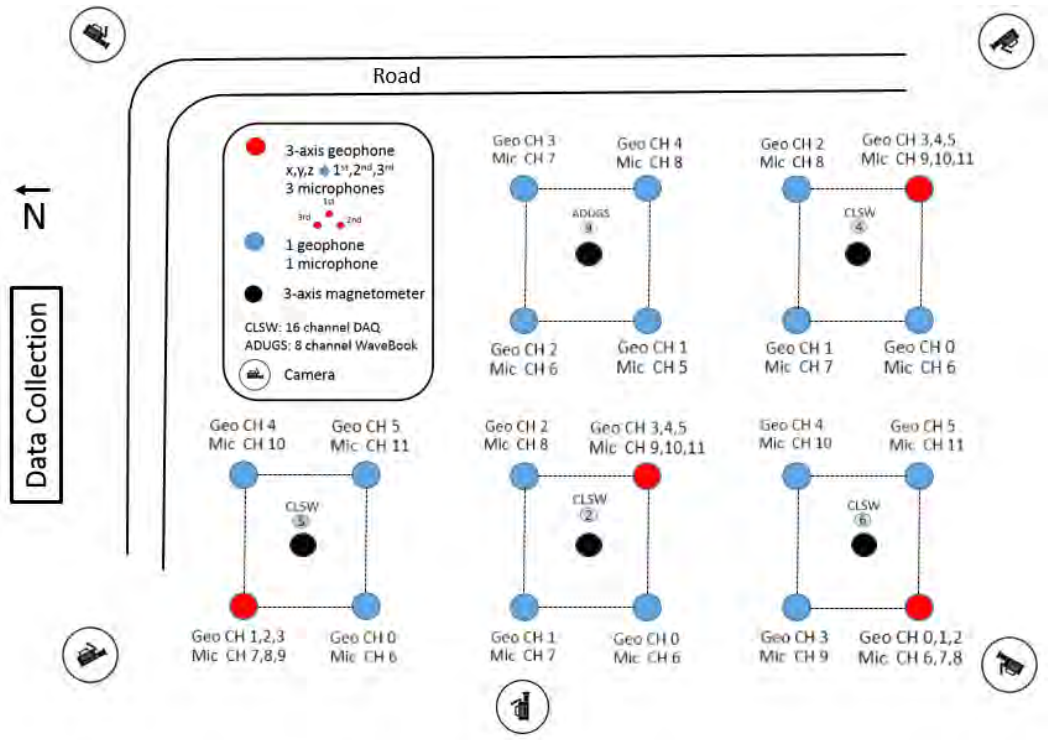


**Fig. 1 Sensor layout grid**

As mentioned earlier, the sensor layout placed the UGS systems 20 m away from each other in a grid pattern. The specific hardware and software used are given in Table 1.

**Table 1 Data collection equipment**

| Name | Description/Manufacturer | No. Used |
|---|---|---|
| Geophone | Geospace GS-11D z-axis or 3-axis xyz configuration | 28 |
| Microphone | Behringer ECM8000 condenser microphone | 28 |
| Magnetometer | Applied Physics Model 1540-digital 3-axis fluxgate | 5 |
| Amplifiers | Alligator Technologies USBPGF-S1 programmable instrumentation amplifier | 5 |
| Data acquisition device 1 | Measurement Computing (IOTECH) WaveBook/ 516E with option WBK13A | 1 |
| Data acquisition device 2 | Measurement Computing (IOTECH) USB-1616HS-BNC | 5 |
| Laptop computers | Dell Latitude E6400 series | |
| Data recording software | DASYLab | 5 |
| Data recording software | WaveView | 1 |
| Global positioning system (GPS) | Garmin e Trex 20x | 12 |
| Camera | Garmin VIRB 010-01088-10 | 5 |
| Cone penetrometer | Kessler DCP K-100 | 1 |

Actual photos of the equipment used for this data collection and their setup are shown in Fig. 2.

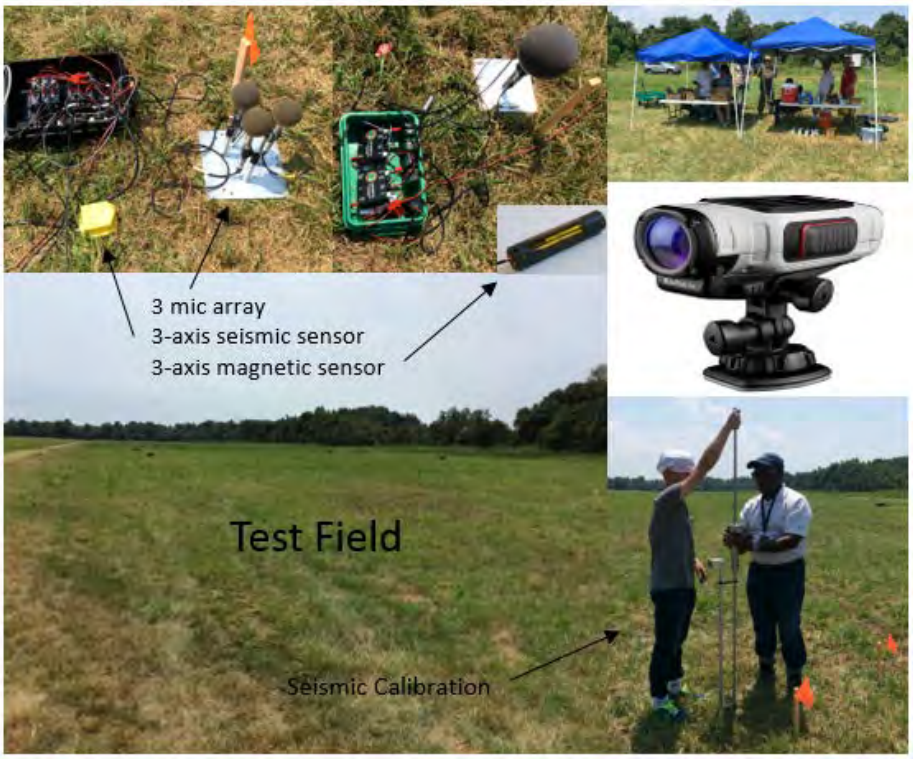


**Fig. 2 Sensor suite used for data collection**

## 3. Data Collection

Several people participated in the data collection to enact various scenarios. The list of participants and their weights are given in Table 2. Also, column 2 corresponds to the GPS receiver each participant carried while enacting a scenario, which tracked that person's location.

**Table 2 Data collection participants**

| Participant (No.) | GPS No. | Weight (lb) |
|---|---|---|
| GC_1 | 4 | 150 |
| TD_2 | 1 | 160 |
| RF_3 | 5 | 160 |
| RH_4 | 6 | 165 |
| MN_5 | 8 | 195 |
| GW_6 | 9 | 204 |
| NS_7 | 3 | 170 |
| SX_8 | 11 | 154 |
| CH_9 | 10 | 200 |
| TW_10 | 7,3 | 170 |
| GW_11 | 2 | 204 |

The data were collected on 3 different days where the first 2 days were walkers ranging from 1–9 persons (Tables 3 and 4) in different formations, which are described later in this section. On the 3rd day, data were collected with different sets of civilian vehicles ranging from sedans to SUVs. Each sensor setup collected seismic, acoustic, and magnetic data. The data were collected at 4096 samples/s and video/GPS locations was recorded to provide ground truth for vehicles and walkers. These data will be used to verify the classification results of the algorithms being developed. To start out testing, a Kessler DCP K-100 cone penetrometer was used to provide a consistent impulse to calibrate the sensors. After calibration, collection of data was started; the activity, participants, and times for each event are outlined in Table 3.

**Table 3 Day 2 walking participants**

| Activity | No. | Participants | Time |
|---|---|---|---|
| Seismic calibration | 3 at10 flags | 5,8 | 1320 |
| 1 person walking | 9 | 1,4,5,6,7,8,9,10,11 | 1335–1428 |
| 9 persons walking | 2 | 1,4,5,6,7,8,9,10,11 | 1430–1434, 1454–1459 |
| 2 persons walking | 4 | (10,11), (8,10), (4,5), (5,11) | 1353–1357, 1400–1403, 1405–1408, 1410–1413 |
| 3 persons walking | 2 | (4,8,9), (1,6,10) | 1415–1419, 1423–1427 |
| 4 persons walking | 2 | (4,8,9,11), (3,5,6,10) | 1430–1433, 1438–1442 |

**Table 4 Day 3 walking participants**

| Activity (No.) | Participants | Times |
|---|---|---|
| Heavy right wedge (1) | 4,6,9,11 | 1017–1025 |
| Diamond (2) | 4,6,9,11 | 1028–1036 |
| Zigzag (3) | 4,6,9,11 | 1043–1050 |
| Line (horizontal) (4) | 4,6,9,11 | 1054–1101 |
| Line (vertical) (5) | 4,6,9,11 | 1115–1122 |
| Double wedge (6) | 1,5,6,8,9,11 | 1134–1138 |
| Formation with diamond in front and 2 men behind (7) | 1,5,6,8,9,11 | 1140–1143 |
| Point man slack man (8) | 1,5,6,8,9,11 | 1143–1147 |
| Diamond leading wedge (9) | 1,2,5,6,8,9,11 | 1340–1350 |
| Diamond with staggered column (10) | 1,2,5,6,8,9,11 | 1358–1409 |
| Heavy left wedge with trailing wedge (11) | 1,2,3,5,6,8,9,11 | 1420–1431 |
| 2 wedges in trail (12) | 1,5,6,8,9,11 | 1500–1505 |
| 2 wedges in line (13) | 1,5,6,8,9,11 | 1513–1515 |
| 2 wedges in line (14) | 1,5,6,8,9,11 | 1519–1521 |

The path each person walked through the sensor field is illustrated in Fig. 3, where the red dotted line indicates the path and the green dot is a walker. There were up to 9 walkers spaced 3 m apart walking single file starting with 1 at a time.

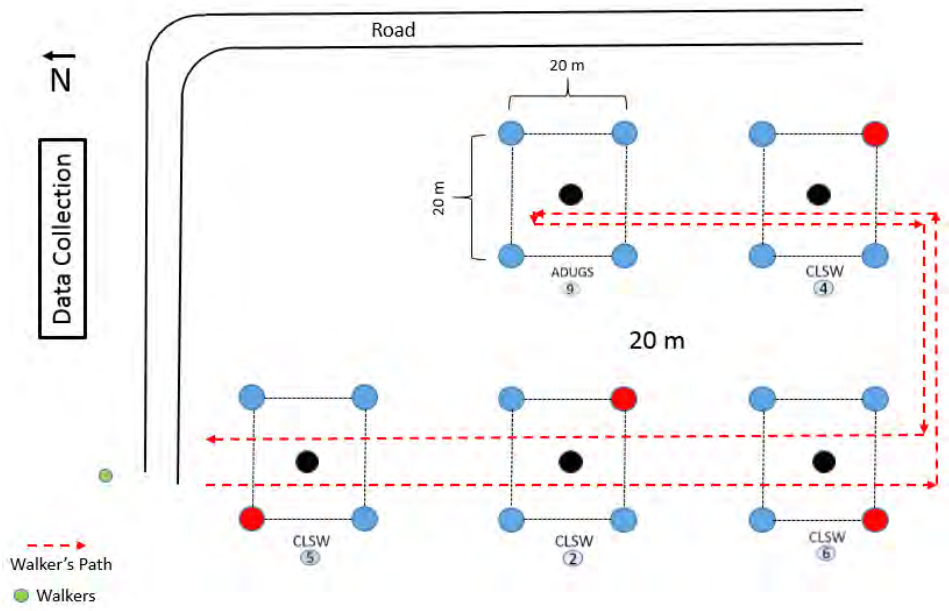


**Fig. 3 Day 2 path for walkers 1–9**

The second day of data collection consisted of many combinations of walkers each carrying a simulated M4 or M16. The activity, participants, and time for each event are shown in Table 4.

The paths each person walked through the sensor field for activities 1–5 are illustrated in Figs. 4–8, where the red dotted line indicates the path and the green dots indicates the walkers' pattern for each activity. The walkers are spaced approximately 5 m apart.

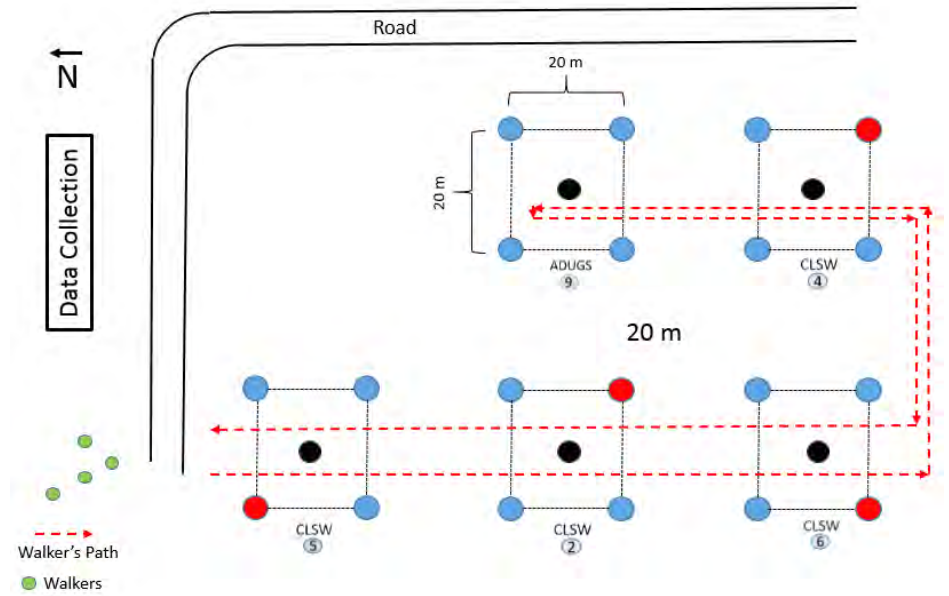


**Fig. 4 Day 3 walker's heavy right wedge pattern**

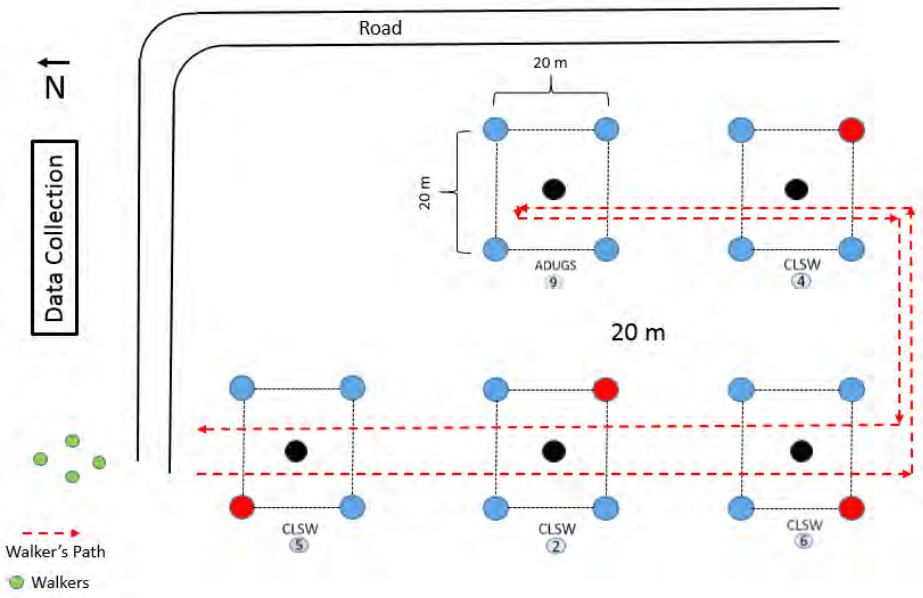


**Fig. 5 Day 3 walker's diamond pattern**

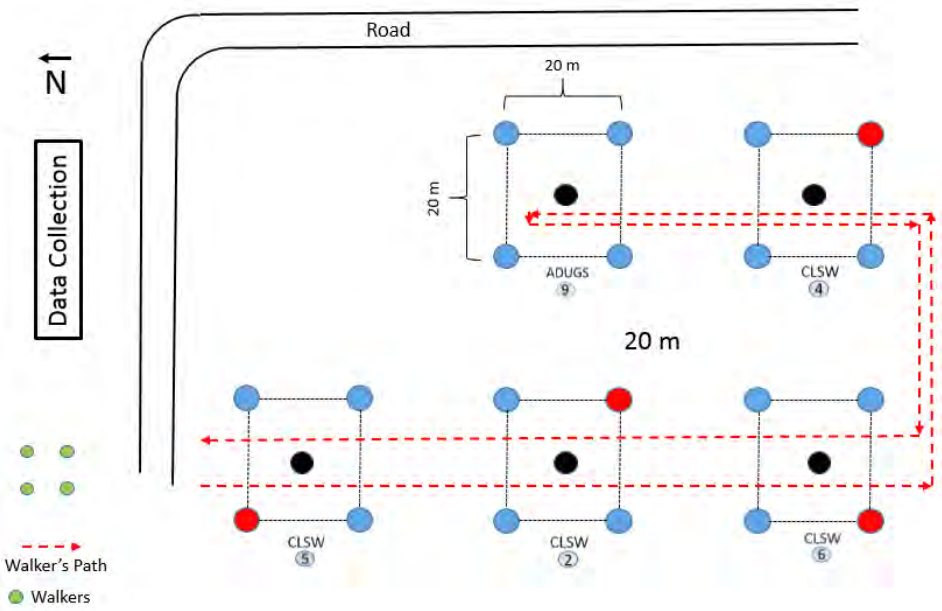


**Fig. 6 Day 3 walker's zig zag pattern**

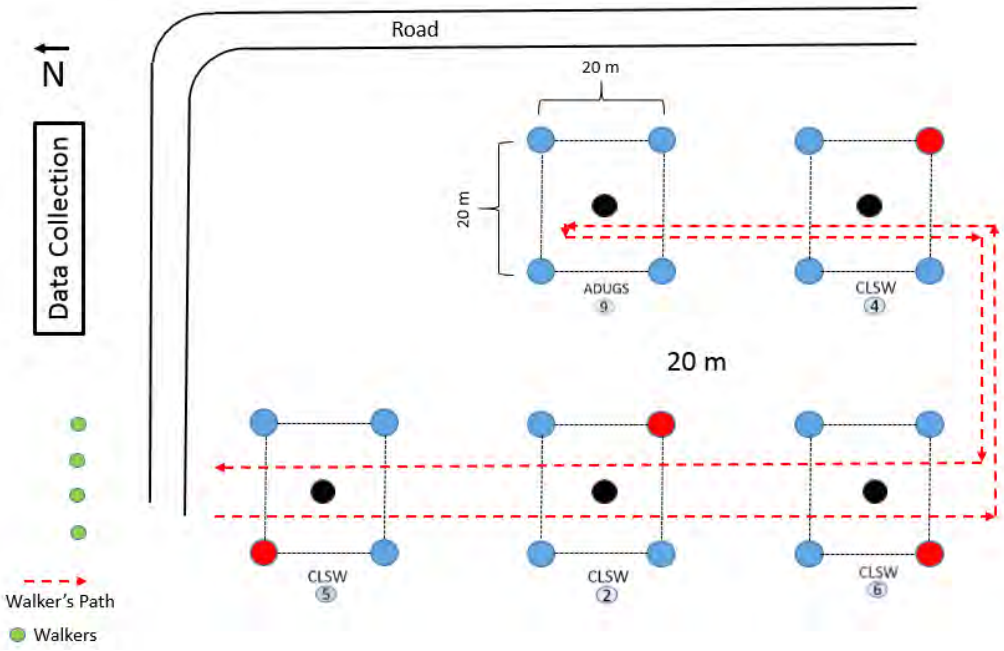


**Fig. 7 Day 3 walker's line horizontal pattern**

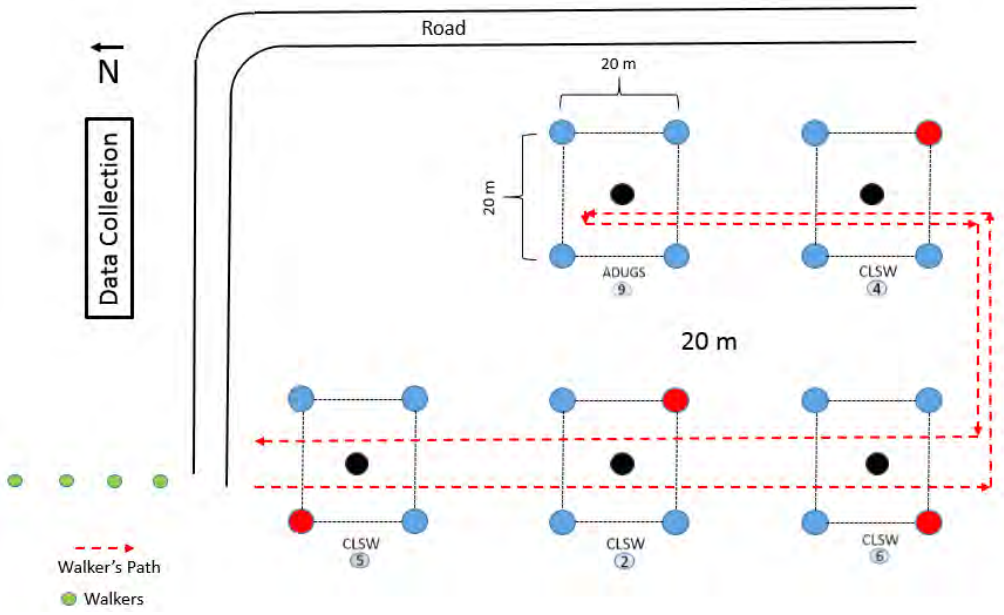


**Fig. 8 Day 3 walker's line vertical pattern**

The paths each person walked through the sensor field for activities 6, 7, and 8 are illustrated in Figs. 9–11, where the red dotted line indicates the path and the green dots indicate the walkers' pattern for each activity. Again, the walkers are spaced approximately 5 m apart.

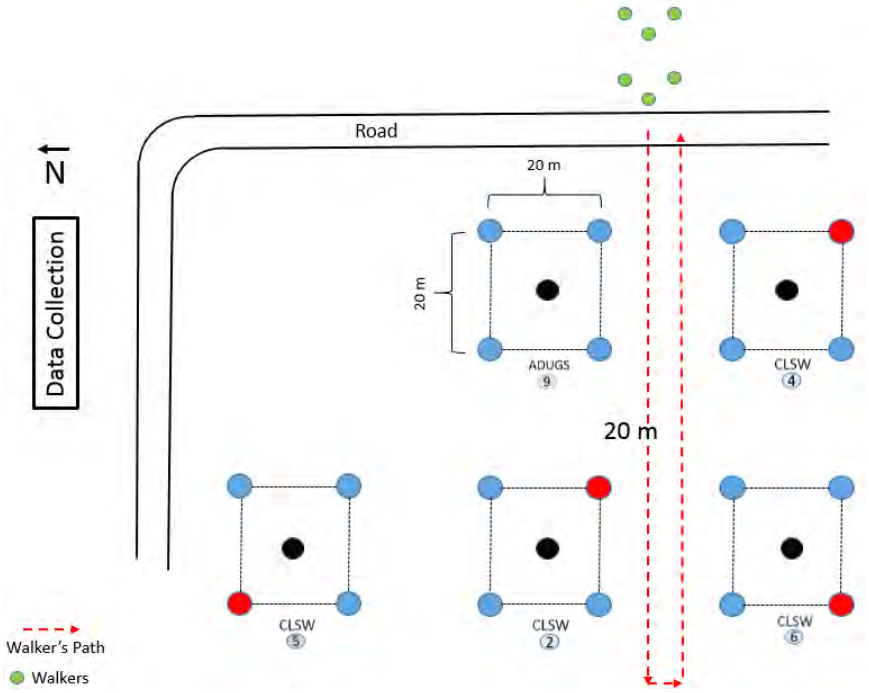


**Fig. 9 Day 3 walker's double wedge pattern**

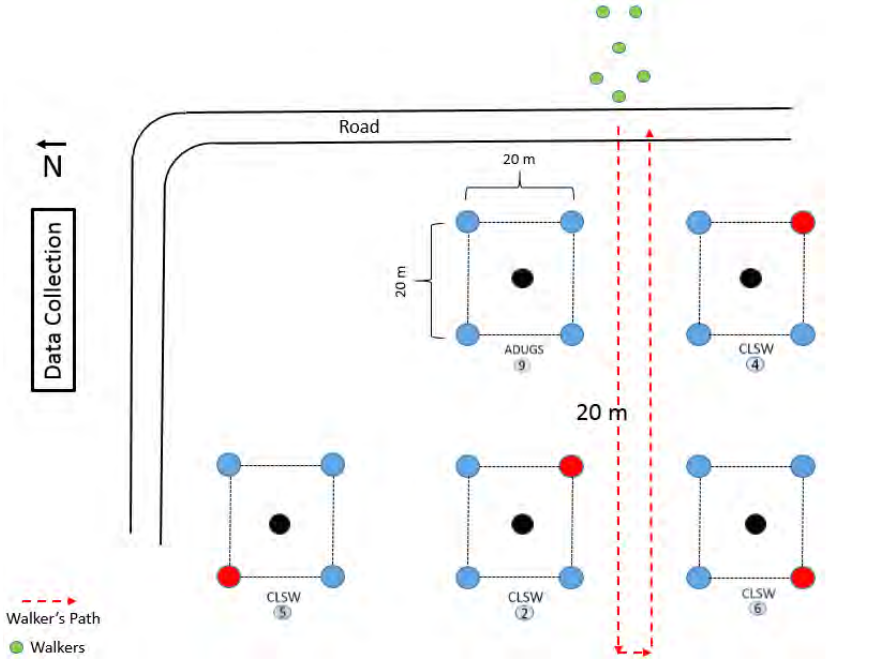


**Fig. 10 Day 3 walker's diamond in front and 2 men behind pattern**

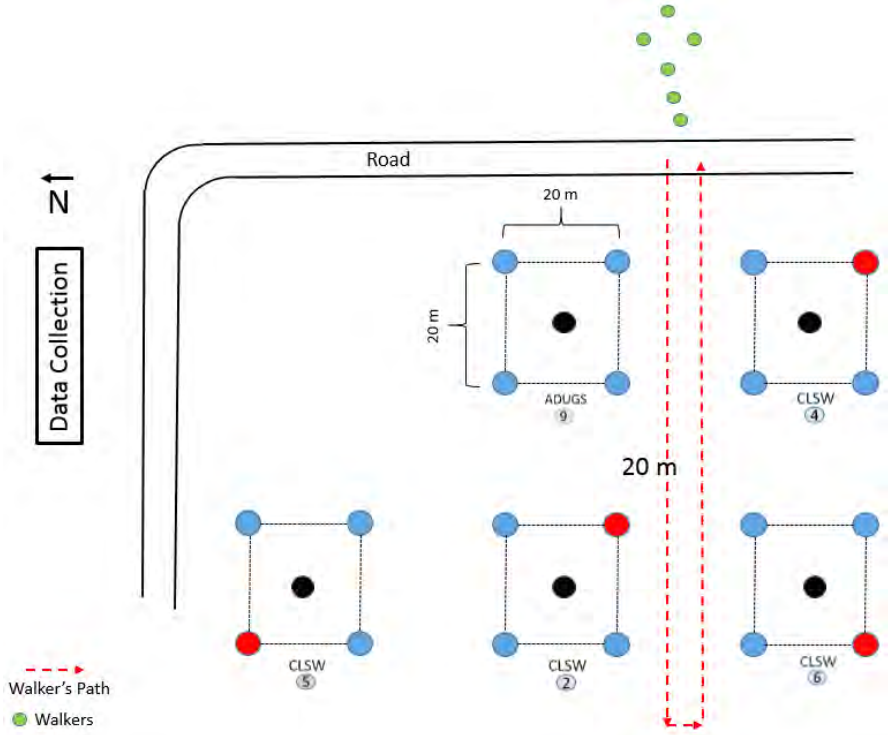


**Fig. 11 Day 3 walker's point man slack man pattern**

The paths each person walked through the sensor field for activities 9, 10, 11, and 12 are illustrated in Figs. 12–15, where the red dotted line indicates the path and the green dots indicates the walker's pattern for each activity. The walkers are also spaced approximately 5 m apart. For activity 12, the participants walk half the route, kneel, and then jog the remaining route for each direction.

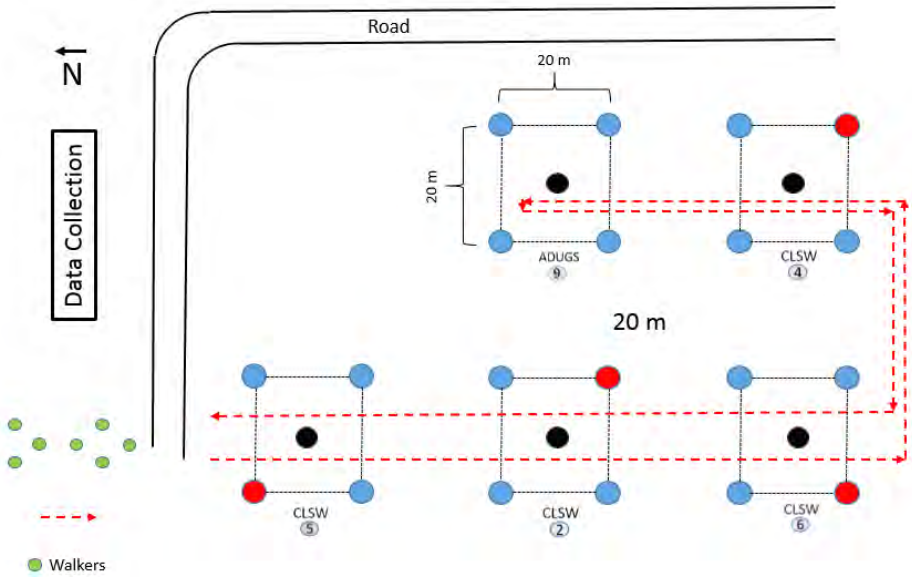


**Fig. 12 Day 3 walker's diamond leading wedge pattern**

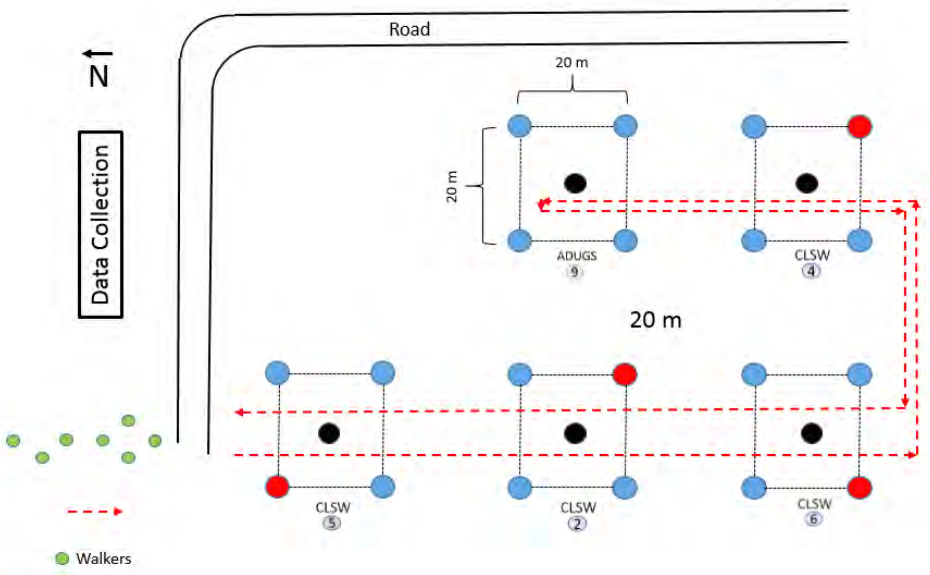


**Fig. 13 Day 3 walker's diamond leading staggered column pattern**

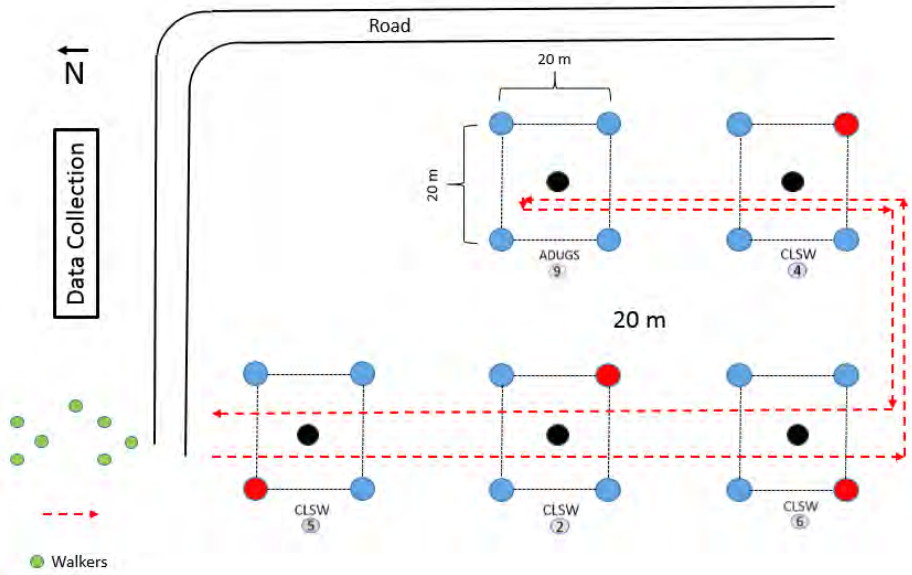


**Fig. 14 Day 3 walker's heavy left wedge with trailing wedge pattern**

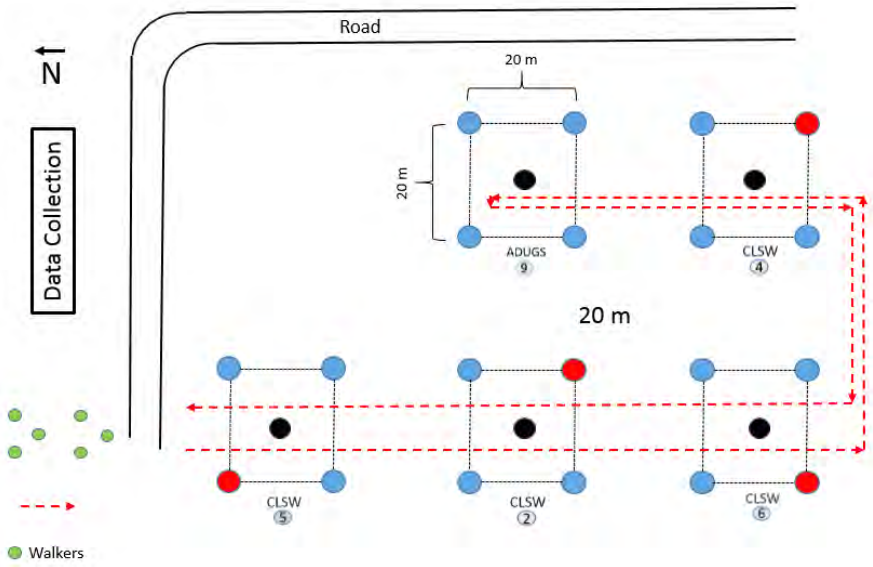


**Fig. 15 Day 3 walker's 2 wedges in trail pattern with jogging**

The paths each person walked through the sensor field for activities 13 and 14 are illustrated in Fig. 16, where the red dotted line indicates the path and the green dots indicate the walkers' pattern for each activity. The walkers are spaced approximately 5 m apart. In both activities, the participants walk across the sensor field, kneel, and then retreat 1 group at a time while the other group covers them.

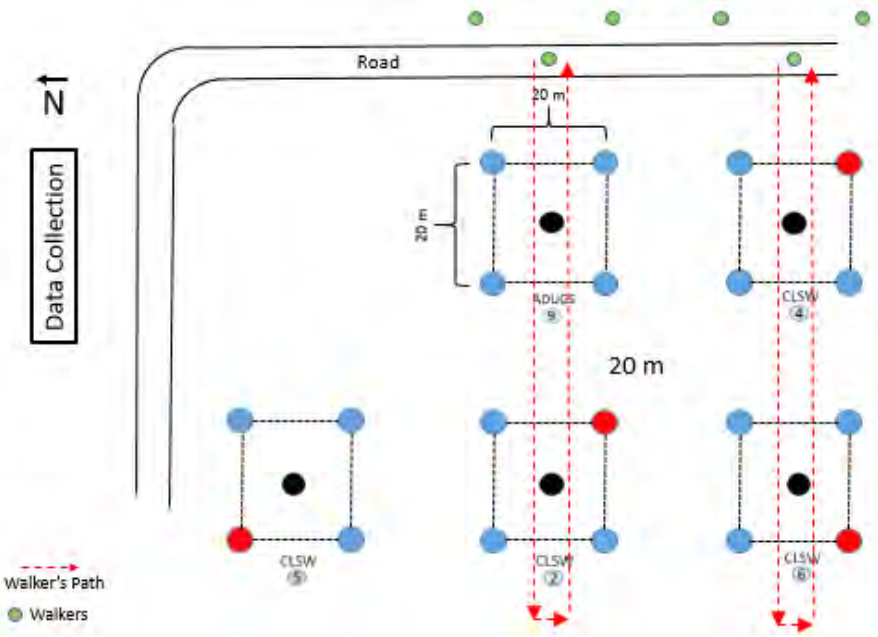


**Fig. 16 Day 3 walker's 2 wedges in trail pattern with covering**

The third day of data collection consisted of driving 1 to 7 vehicles around the sensor field. The data collection consisted of driving around the sensor field starting

with 1 vehicle and incrementing by one up to 6 total vehicles. The vehicles were spaced 10 ms apart traveling 10 mph. The activity, participants, and time for these events are shown in Table 5 and the driving pattern is illustrated in Fig. 17.

**Table 5 Day 3 vehicle participants, driving around a field**

| Activity | Time | Participants |
|---|---|---|
| 1 vehicle around field twice | 10:11–10:15 am | 11 |
| 1 vehicle around field twice | 10:15–10:19 am | 9 |
| 1 vehicle around field twice | 10:19–10:23 am | 1 |
| 1 vehicle around field twice | 10:23–10:27 am | 6 |
| 1 vehicle around field twice | 10:27–10:31 am | 3 |
| 1 vehicle around field twice | 10:31–10:34 am | 10 |
| 2 vehicles around field twice | 10:48–10:51 am | 9,11 |
| 3 vehicles around field twice | 10:52–10:56 am | 1, 9, 11 |
| 4 vehicles around field twice | 10:57–11:01 am | 1, 6, 9, 11 |
| 5 vehicles around field twice | 11:02–11:06 am | 1, 3, 6, 9, 11 |
| 6 vehicles around field twice | 11:06–11:10 am | 1, 3, 6, 9, 10, 11 |

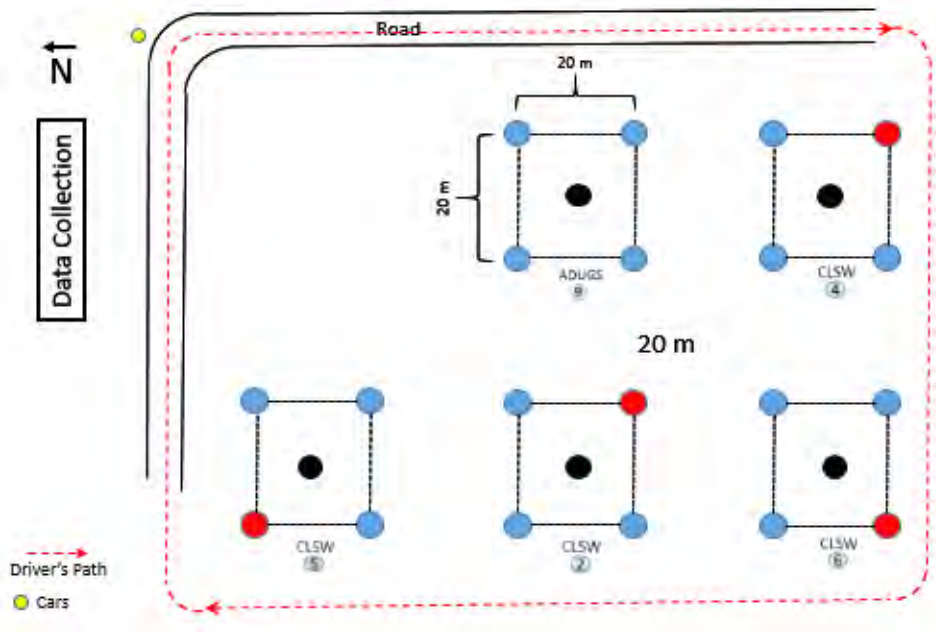


**Fig. 17 Day 4 vehicles driving around the sensor field**

The second data collection consisted of vehicles driving up and back on the dirt road next to the sensor field. The test started with 1 vehicle and incremented by 1 up to 7 total vehicles. The vehicles were spaced 10 m apart traveling 20 mph going up the road to a turnaround point (about a ¼ mile past the sensor field) and 30 mph coming back. The activity, participants, and time for these events are shown in Table 6 and the driving pattern is illustrated in Fig. 18.

**Table 6 Day 3 vehicle participants, driving on a road**

| Activity | Time | Participants |
|---|---|---|
| 1 vehicle down and back on a road | 11:30–11:33 am | 11 |
| 2 vehicles down and back on a road | 11:34–11:38 am | 9,11 |
| 3 vehicles down and back on a road | 11:39–11:42 am | 1, 9, 11 |
| 4 vehicles down and back on a road | 11:43–11:46 am | 1, 6, 9, 11 |
| 5 vehicles down and back on a road | 11:47–11:51 am | 1, 6, 9, 10, 11 |
| 6 vehicles down and back on a road | 11:51–11:55 am | 1, 3, 6, 9, 10, 11 |
| 7 vehicles down and back on a road | 11:57 am–12:01 pm | 1,2, 3, 6, 9, 10, 11 |

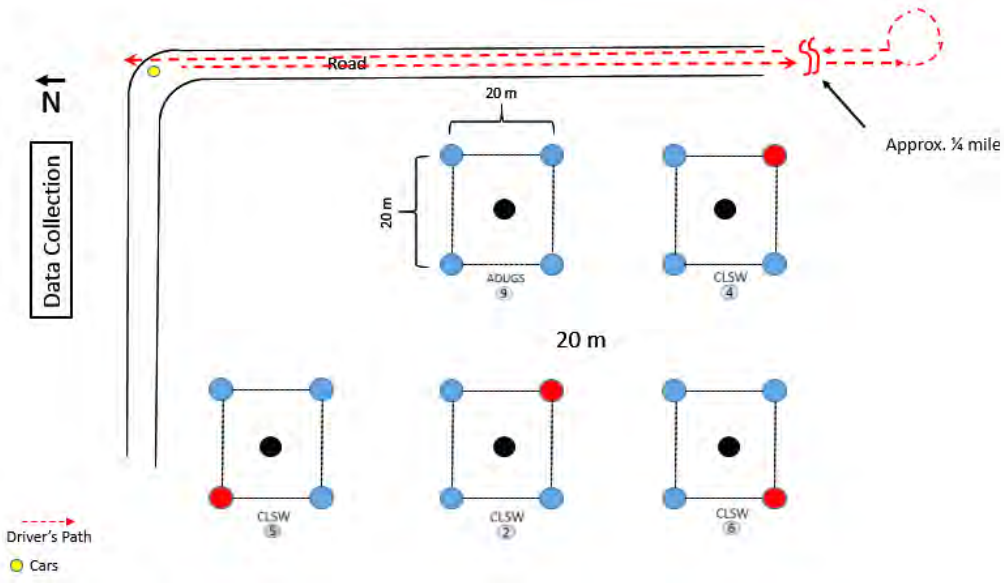


**Fig. 18 Day 4 vehicles driving up and back on the road next to the sensor field**

The third data collection consisted of vehicles driving pattern through the sensor field. The test started with 1 vehicle and incremented by 1 up to 3 total vehicles. The vehicles were spaced 10 ms apart traveling 10 mph. The activity, participants, and time for these events are shown in Table 7 and the driving pattern is illustrated in Fig. 19.

**Table 7 Day 3 vehicle participants, driving a pattern**

| Activity | Time | Participants |
|---|---|---|
| 1 vehicle driving a pattern through field | 12:30–12:37 pm | 11 |
| 2 vehicles driving a pattern through field | 12:38–12:44 pm | 9,11 |
| 3 vehicles driving a pattern through field | 12:44–12:51 pm | 1, 9, 11 |

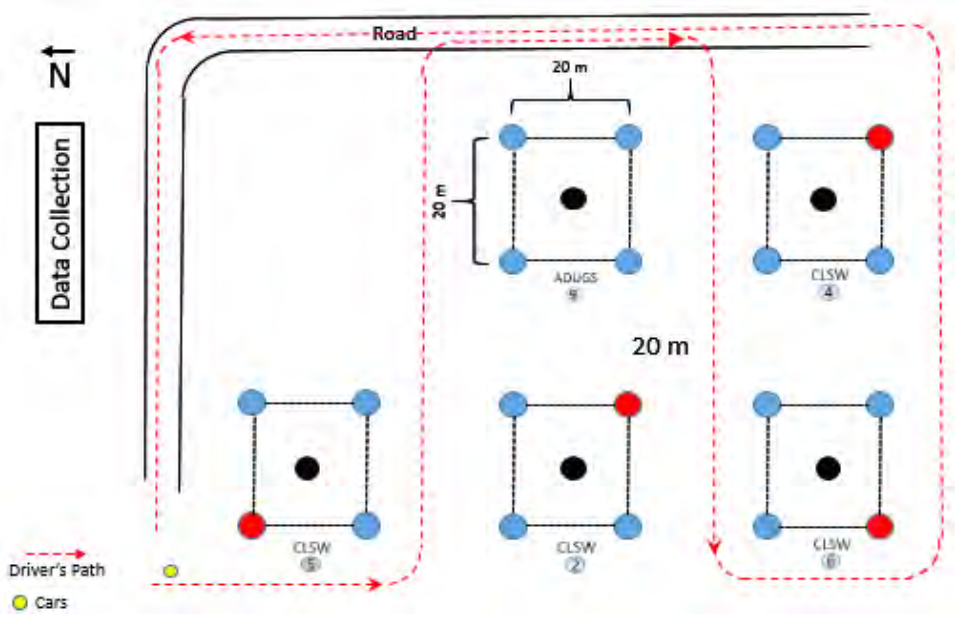


**Fig. 19 Day 4 vehicles' driving pattern through the sensor field**

Typical data collected using acoustic and seismic sensor are shown in Figs. 20 and 21, respectively.

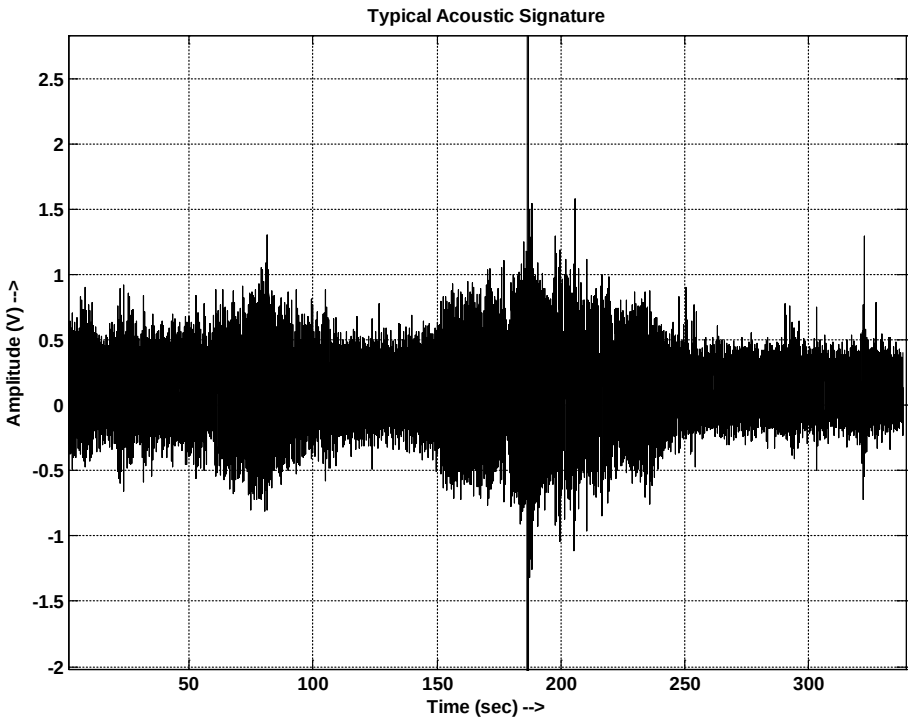


**Fig. 20 Typical acoustic signature**

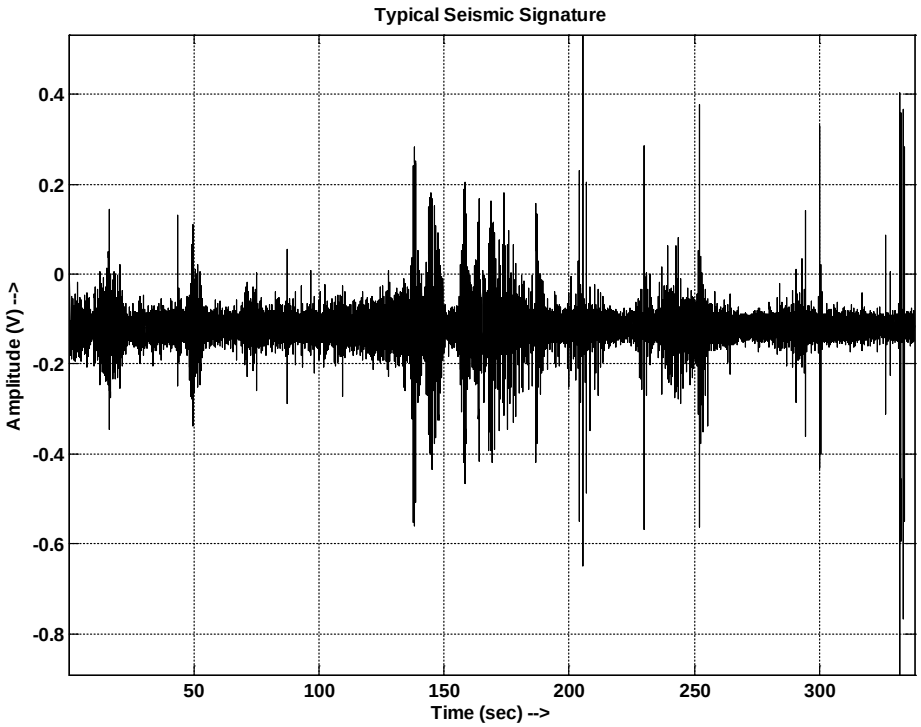


**Fig. 21 Typical seismic signature**

## 4. Conclusion

The data collection of sensor signatures taken on Spesutie Island at Aberdeen Proving Grounds, Maryland, from July 27–30, 2015, will allow researchers to develop cutting-edge detection algorithms that can detect and classify 1 or more vehicles or persons. This report provides specific information on the data collection setup to include equipment used. There is additional documentation available that provides video, GPS track location, and other information regarding experiment, available upon request from the authors.

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